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Borg-Warner Corporation

INGERSOLL KALAMAZOO DIVISION
1810 North Pitcher Street, Kalamazoo, Michigan

INTERIM REPORT NO. 1
on

CONTRACT NOnr-2459(00)

"Airoll" Vehicle Locomotion Study

April 1960

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INGERSOLL KALAMAZOO DIVISION
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CONCLUSIONS

Testing to date of the Airoll Test Platform designed, developed and fabricated under Contract NOnr-2459(00) has enabled the Design Agent to arrive at the following conclusions concerning this new locomotion concept:

Rolling resistance of the Airoll Test Platform is comparable to that of other track laying vehicles operating on a hard, level surface. Smooth tread terra tires, sized 24 x 24-6 and 16 x 24-6, at 15 psi tire pressure, were used. The rolling resistance with lower tire pressures is greater than that of other track laying vehicles.

The Design Agent is convinced that additional design and development of the track and track guidance system can reduce the track tension and rolling resistance.

Rolling resistance in cross-country operation of the Airoll Test Platform was found to be less than that of other track laying vehicles because of the low pressure tires which conform to terrain irregularities.

The Airoll Test Platform has demonstrated excellent mobility in mud and swamp operation. However, snow operation has indicated that substantial improvement could be expected through utilization of a treaded tire in place of the smooth tread type which had a tendency to slip on packed snow.

The present lead-in angle on the sponson provides excellent rideability with terra tire 16 x 24-6, but a loping characteristic develops with terra tire 24 x 24-6 and industrial tire 23 x 8.00-10 during level surface operation. It is the opinion of the Design Agent that additional research and development can improve the unit's ride characteristics considerably.

INTRODUCTION

Department of the Navy, Office of Naval Research Contract NOnr-2459(00) has been established to prove the feasibility and practicability of a locomotion concept incorporating two or more tracks, each of which is driven by a sprocket or other suitable means. Each track in turn consists of a series of free-running tires or rollers connected to an endless chain or belt. Motion is produced by track tension which causes the vehicle to roll over the tires which also act as the suspension system.

Scope

Contract NOnr-2459(00), which is a joint venture with the Borg-Warner Research Center at Des Plaines, Illinois, consists of two phases:

Phase I. Conduct a mathematical study of a locomotion vehicle concept to determine the basic parameters and delineation of specific values necessary for the construction of a suitable test bed.

Phase II. Design and construct a test bed suitable for further evaluation of the potentialities of this locomotion system The test bed design shall provide for the variation and control of the parameters basic to this concept. Configuration shall consist of, but not necessarily be limited to, the type and sizes of the tires, the tire pressures to be used, the best length/width ratio, and the horsepower necessary for operation. The actual design and construction shall be aimed

toward producing the simplest possible test rig compatible with test requirements. Standard automotive engines, transmissions, and drive shafts shall be used. One of the available control or steering differentials shall also be used to direct power to the sprockets. The track design shall be mainly limited to strength requirements.

AIROLL TEST PLATFORM

Fabrication of the Airoll Test Platform was completed in March 1959. The test platform was provided with spacers to produce track length-to-width ratios of 1:1 and 1.5:1 illustrated in Figures 1 and 2. Initial tests are to be conducted with a track length-to-width ratio of 1:1 on the three following track types:

1. Track equipped with Goodyear Tire and Rubber Company terra tire 24 x 24-6, smooth tread, 16 tires per track.
2. Track equipped with Goodyear Tire and Rubber Company terra tire 16 x 24-6, smooth tread, 19 tires per track.
3. Track equipped with industrial tire 23 x 8.00-10, two tires per axle, 32 tires per track.

A test program and test agenda (see Supporting Data Section) were prepared to determine the basic engineering information for a track length-to-width ratio of 1:1 utilizing the track equipped with the smooth tread terra tire 24 x 24-6. Part I, C and Part II of the Test Agenda is to be conducted on the track equipped with the smooth tread terra tire 16 x 24-6 and the track equipped with industrial tires 23 x 8.00-10, both with a track length-to-width ratio of 1:1.

As the test program progressed a portion of the test results indicated that additional testing would be required, due to inaccuracies in the data obtained

(see Status of Testing Section). Coordination of use of the test equipment with other existing projects made it necessary to modify to a minor degree the sequence of testing. Unavailability of adequate test facilities for production of accurate results also called for rerunning of some portions of the test program.

The net weight of the test platform as constructed totaled 19,500 pounds. Consequently, a program was established to remove from the test platform any weight that did not contribute to the structural strength of the unit. As a results, a reduction weight of 2,000 pounds was accomplished.

STATUS OF THE TEST PROGRAM

Track equipped with terra tire 24 x 24-6, smooth tread.

Part I. Static and dynamic testing that does not require electronic instrumentation.

A. Preoperational information, completed.

1. Net weight . . . . 17,500 pounds.
2. Center of gravity
   a. Longitudinal center of gravity . 104 inches forward of the rear drive sprocket center line.
   b. Vertical center of gravity . . . 1-5/8 inches below the top of the sponson.
   c. Transverse center of gravity . On the longitudinal center line.

B. Power train break-in, completed.

C. Rolling resistance, incomplete.

1. Item C.4. completed. Accurate data was not obtained (see Table 1). An adequate test course and test equipment were not available at this time.

Part II. Power testing, incomplete.

1. Use of the 60,000 lb.in. torquemeters was coordinated with

Contract NObs-3597. They were installed in the power train and calibrated (see Table 5). Very little information was obtained before the power train failure resulted in considerable down time and the torquemeters were required on Contract NObs-3597.

Part III. Vibration and Ride Characteristics.

1. All work has been completed at this test facility. The data obtained with electronic instrumentation will be processed and reduced to a usable form by the Borg-Warner Research Center. A portion of this test utilized photographic coverage (moving pictures) and these are being prepared for distribution.

Track equipped with terra tire 16 x 24-6, smooth tread.

Testing of the test platform under this phase consisted of repeating Part I, C. and Part II of the Test Agenda (see Supporting Data Section) using the 24 x 24-6 tires. The rolling resistance phase has been completed satisfactorily (Tables 2, 3 and 4 and Graphs 1, 2 and 3) with adequate test equipment to accurately measure track tension. Analysis of previous test data indicated that reducing the number of test runs from tire pressures of 4 psi, 8 psi, 12 psi and 15 psi to 5 psi, 10 psi and 15 psi, adequate engineering information can be obtained.

Torquemeters were not available for power train testing at this time

but this phase will be conducted at a later date.

A tractive effort test was conducted with this track at tire pressures of 5 psi, 10 psi and 15 psi. The test was not completed due to weather conditions and a drawbar failure. The data obtained was recorded on Table 6. Additional information on terra tire 16 x 24-6, smooth tread, is contained on Tables 7 and 8, and Graphs 4 and 5.

Track equipped with industrial tire 23 x 8.00-10.

Testing of the test platform consisted of repeating Part I, C. and Part II of the Test Agenda. This tire is presently installed, but a final drive chain sprocket failure has delayed testing for approximately eight weeks.

NOTE:. Portions of the Test Agenda not completed on the various tracks will be re-run at a later date.

SUPPORTING DATA

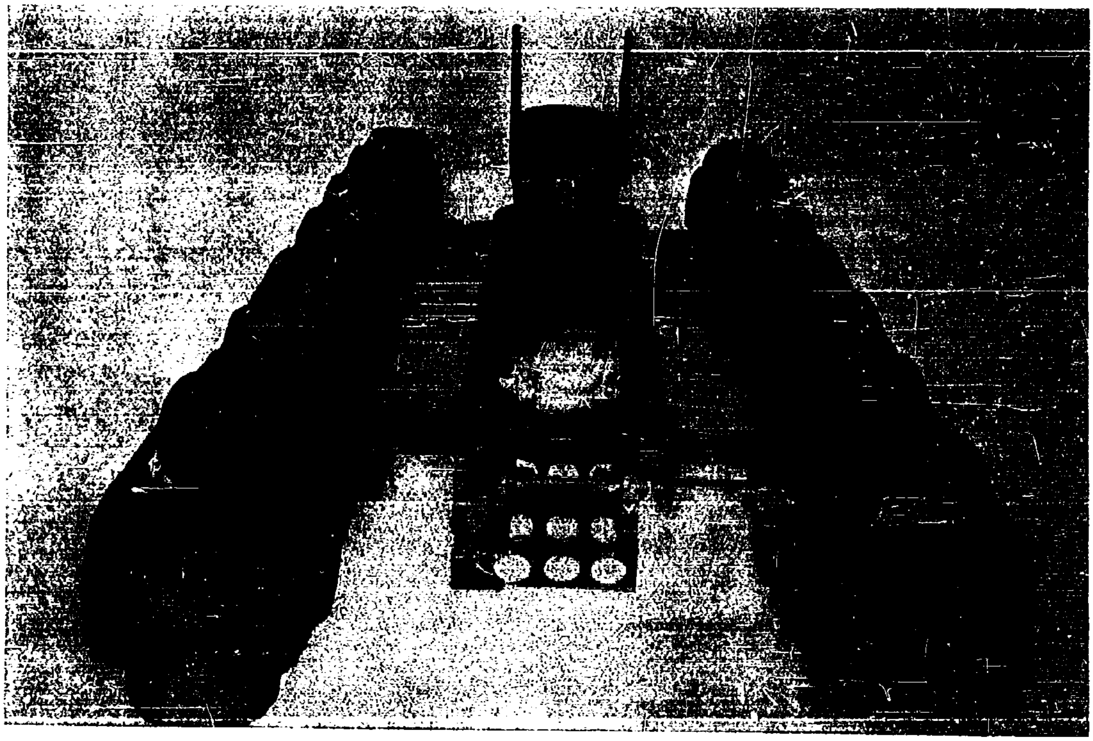


Figure 1. Airoll Test Platform, Track Length-to-Width Ratio 1:1, Terra Tire 24 x 24-6.

Figure 2. Airoll Test Platform, Track Length-to-Width Ratio 1.5:1, Terra Tire 24 x 24-6.

Figure 3. Airoll Test Platform, Track Length-to-Width Ratio 1.5:1, Terra Tire 24 x 24-6.

Figure 4. Airoll Test Platform, Track Length-to-Width Ratio 1:1, Terra Tire 16 x 24-6.

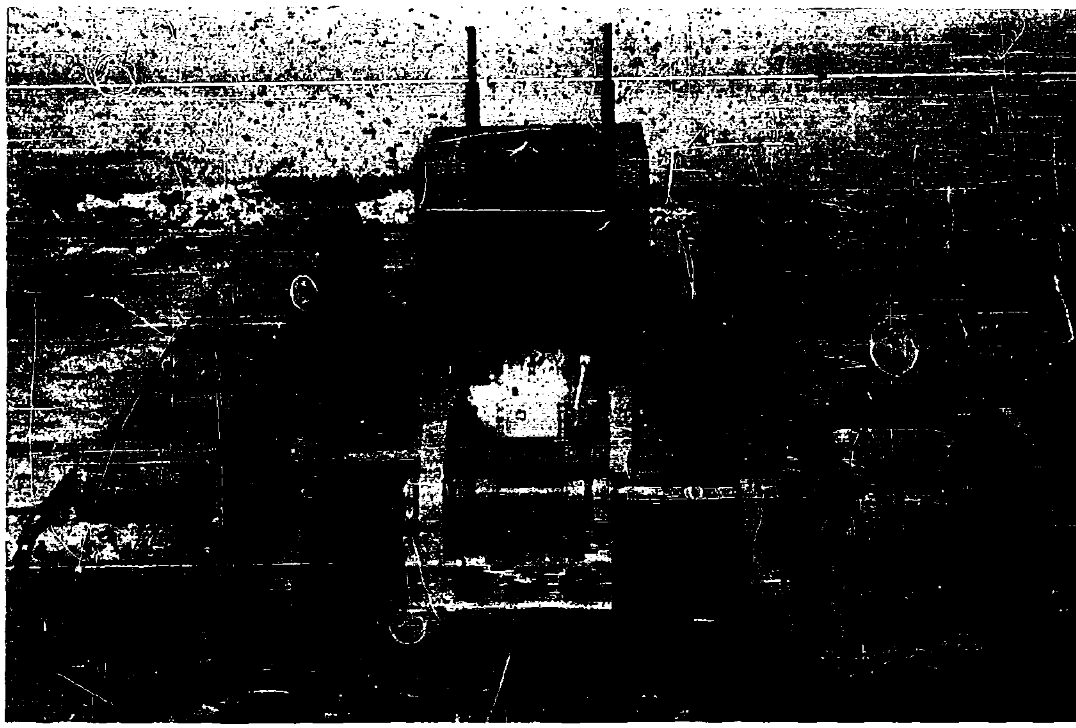


Figure 5. Airoll Test Platform, Track Length-to-Width Ratio 1:1, Terra Tire 16 x 24-6.

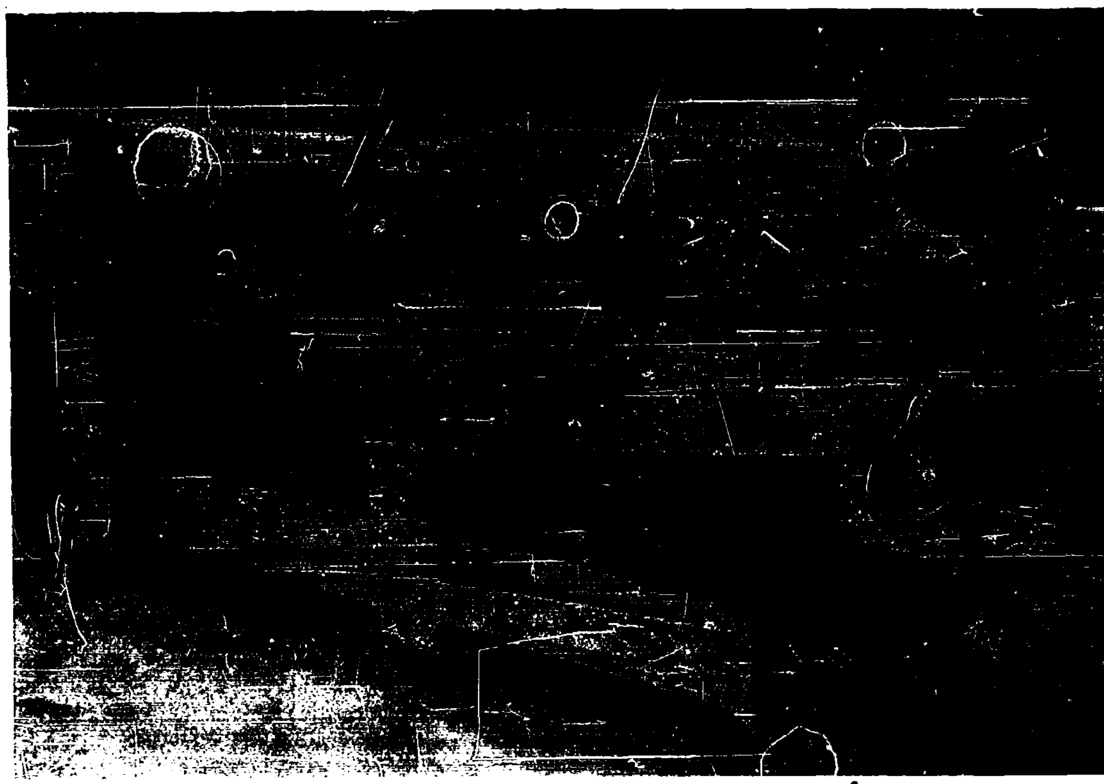


Figure 6. Airoll Test Platform, Starboard Front Track Guide, Terra Tire 16 x 24-6.

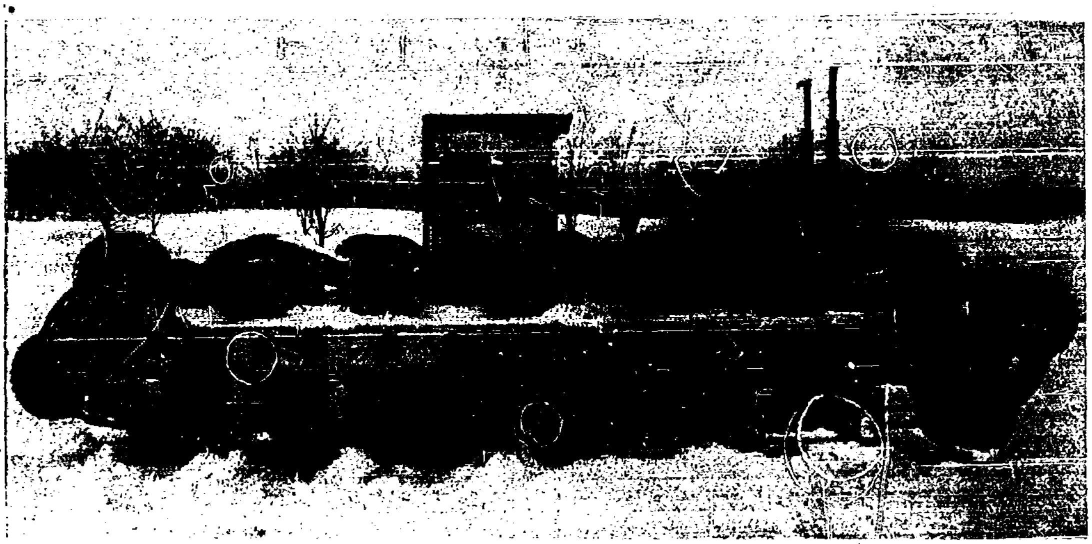


Figure 7. Airoll Test Platform, Track Length-to-Width Ratio 1:1, Industrial Tire 23 x 8:00-10.

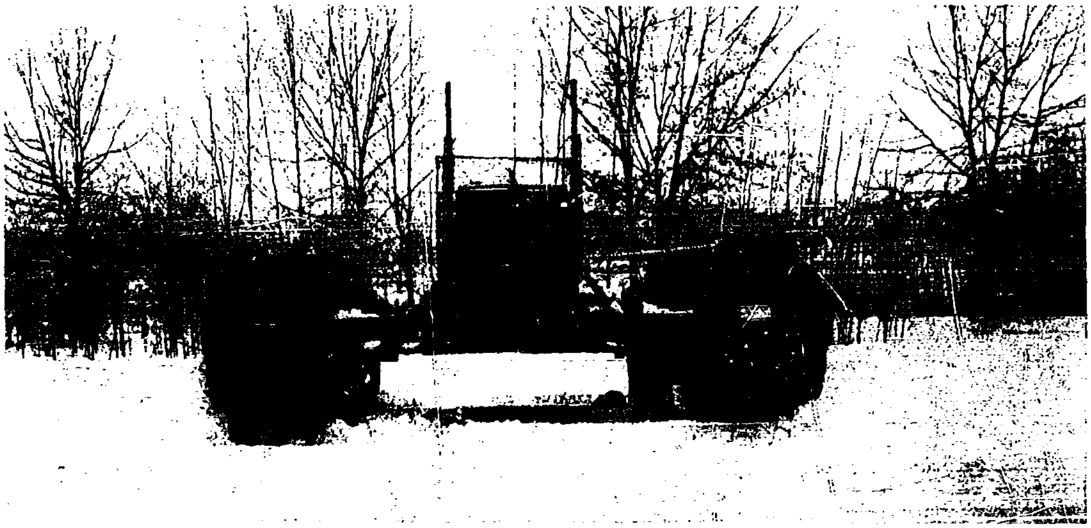


Figure 8. Airoll Test Platform, Track Length-to-Width Ratio 1:1, Industrial Tire 23 x 8:00-10.

Figure 9. Airoll Test Platform, Starboard Front View, Industrial Tire 23 x 8:00-10.

Figure 10. Airoll Test Platform, Port Rear View, Industrial Tire 23 x 8:00-10.

Table 1. Rolling Resistance Data

(Terra Tire 24 x 24-6, smooth tread. Track tension in excess of 10,000 pounds. Air temperature 80°F. - 90°F. Constant force per square inch - 923 pounds. Airoll weight - 9.25 tons.)

Speed mph	Area Under 6 Inch Section of Wheel Curve Square Inches 1	2	3	Average Area Square Inches	Average Total Force Under 6 In. Section of Wheel Curve. Pounds	Total Drawbar Pull	Rolling Resistance
Tire Pressure - 15 psi							
5.76	3.12	2.99	3.61	3.24	2,985	498	53.8
11.15	4.45	5.62	6.85	5.64	5,200	867	93.8
14.50	7.63	9.30		8.47	7,815	1,302	140.9
20.1	6.42	8.14	8.87	7.81	7,210	1,202	130.1
Tire Pressure - 12 psi							
4.76	5.08	5.20	4.67	4.98	4,600	767	83.0
10.30	5.94	5.35	5.98	5.76	5,320	887	96.0
15.10	5.67	5.31	5.14	5.37	4,855	809	87.5
20.20	9.33	8.13	6.31	7.92	7,305	1,218	131.7
Tire Pressure - 8 psi							
4.50	6.08	5.91	5.81	5.93	5,360	893	96.7
9.50	6.19	6.28	5.83	6.10	5,630	938	101.3
16.2	8.25	6.93	6.53	7.24	6,680	1,113	120.5
17.5	10.68	10.44	10.02	10.38	9,560	1,593	172.6
Tire Pressure - 4 psi							
4.84	8.42	8.08	7.72	8.07	7,450	1,242	134.5
9.75	9.39	8.72	8.62	8.91	8,230	1,372	148.5
13.90	10.15	9.60	9.28	9.68	8,840	1,473	159.4
16.65	12.41	12.12	11.57	12.03	11,100	1,850	200.0

Table 2. Rolling Resistance Data

(Terra Tire 16 x 24-6, smooth tread. Tire pressure 15 psi. Constant force per square inch - 923 pounds. Air temperature 15° F. - 30°F. Airoll weight - 9.225 tons.)

Speed mph	Area Under 6 Inch Section of Wheel Curve Square Inches 1	2	3	Average Area Square Inches	Average Total Force Under 6 In. Section of Wheel Curve Pounds	Total Drawbar Pull	Rolling Resist-ance
Approximate Track Tension - 10,000 Pounds							
4.7	5.62	4.92	5.43	5.32	4,910	818	88.7
10.3	5.64	6.17	5.59	5.80	5,355	893	96.8
15.0	5.76	5.82	5.88	5.82	5,370	895	97.0
19.4	6.56	6.82	6.64	6.67	6,160	1,032	112.0
24.0	6.68	6.56	6.55	6.60	6,090	1,015	110.2
31.5	4.04	4.79	7.36	5.40	4,980	830	90.0
Approximate Track Tension - 5,000 Pounds							
4.5	5.01	3.80	4.65	4.49	4,145	692	75.1
9.9	4.05	3.90	3.77	3.91	3,605	602	65.3
15.3	4.27	4.61	4.43	4.44	4,100	683	74.0
20.6	4.48	4.50	4.39	4.46	4,115	686	74.4
25.6	4.03	3.91	3.42	3.79	3,500	586	63.5
31.5	4.63	2.85	2.71	3.40	3,135	523	56.8
Approximate Track Tension - 2,500 Pounds							
5.5	4.86	4.48		4.67	4,310	718	77.8
10.4	4.95	5.14	4.95	5.01	4,670	778	84.3
15.6	5.25	5.82		5.54	5,110	852	92.4
20.1	5.69	6.28	5.52	5.83	5,380	897	97.3
25.6	6.23	6.24	6.18	6.22	5,745	958	103.8
30.1	4.28	5.17	4.73	4.73	4,370	728	78.9
35.1	5.51	3.28	4.76	4.52	4,170	695	75.3

Table 3. Rolling Resistance Data

(Terra Tire 16 x 24-6, smooth tread. Tire pressure 10 psi. Constant force per square inch - 923 pounds. Air temperature 15°F. - 30°F. Airoll weight - 9.225 tons.)

Speed mph	Area Under 6 Inch Section of Wheel Curve, Square Inches 1	2	3	Average Area Square Inches	Average Total Force Under 6 In. Section of Wheel Curve Pounds	Total Drawbar Pull	Rolling Resistance
Approximate Track Tension - 10,000 Pounds							
5.5	5.94	6.83		6.39	5,895	983	106.4
10.0	6.44	6.52		6.48	5,980	997	108.1
15.3	6.60	7.29		6.95	6,410	1,068	115.7
20.4	6.82	6.81		6.81	6,285	1,048	113.7
25.1	6.54	6.77		6.66	6,150	1,025	111.2
30.2	6.58	6.29		6.44	5,840	973	105.3
34.6	6.01	6.61	6.13	5.92	5,465	911	98.7
Approximate Track Tension - 5,000 Pounds							
6.0	7.56	6.40	4.83	6.26	5,780	963	104.3
10.8	5.82	5.25		5.54	5,110	852	92.4
15.6	5.04	5.28		5.16	4,760	793	86.0
20.4	6.54	5.98		6.26	5,780	963	104.3
24.8	6.17	6.02		6.10	5,635	939	101.7
30.7	6.55	5.45		6.00	5,540	923	100.0
33.0	4.49	4.61	4.49	4.53	4,180	697	75.6
Approximate Track Tension - 2,500 Pounds							
5.7	5.62	5.66		5.64	5,205	868	94.1
11.5	5.82	5.92		5.87	5,410	902	97.8
15.7	5.92	6.04		5.98	5,515	919	99.6
21.0	7.21	7.41	7.13	7.25	6,690	1,132	122.9
25.7	6.92	6.60		6.76	6,240	1,040	112.8
30.5	5.81	5.98		5.89	5,430	905	98.1
35.4	5.31	5.57		5.44	5,015	836	90.7

Table 4. Rolling Resistance Data

(Terra Tire 16 x 24-6, smooth tread. Tire pressure 5 psi. Constant force per square inch - 923 pounds. Air temperature 15°F. - 30°F. Airoll weight - 9.225 tons.)

Speed mph	Area Under 6 Inch Section of Wheel Curve Square Inches 1	2	3	Average Area Square Inches	Average Total Force Under 6 In. Section of Wheel Curve Pounds	Total Drawbar Pull	Rolling Resistance
Approximate Track Tension - 10,000 Pounds							
5.5	8.60	8.72		8.66	7,995	1,332	144.6
10.4	8.30	8.26		8.28	7,645	1,274	138.1
15.8	8.49	8.65		8.57	7,805	1,301	141.1
20.8	8.68	8.93		9.15	8,445	1,408	152.7
25.2	9.18	9.08		9.13	8,420	1,403	152.2
30.7	7.56	7.94		7.75	7,150	1,192	129.3
Approximate Track Tension - 5,000 Pounds							
5.7	7.48	7.43		7.45	6,870	1,145	124.2
10.0	7.53	7.40		7.47	6,895	1,149	124.6
15.5	7.16	7.40		7.28	6,715	1,119	121.3
20.5	7.69	8.63		8.16	7,535	1,256	136.1
25.1	8.29	7.85		8.07	7,450	1,240	134.5
31.1	7.22	8.23		7.73	7,130	1,188	128.8
Approximate Track Tension - 2,500 Pounds							
5.1	8.38	7.88		8.13	7,500	1,250	135.5
10.7	7.55	7.85		7.70	7,105	1,183	128.3
15.3	7.98	7.95		7.97	7,355	1,226	122.9
20.2	8.88	8.94		8.91	8,235	1,374	149.1
25.1	8.52	8.73		8.63	7,960	1,327	143.8
30.6	7.23	7.81		7.52	6,840	1,140	123.7

Table 5. Steering Torques

(Tire size 24 x 24-6, smooth tread. Tire pressure 15 psi. Surface - brushed concrete. Airoll weight - 9.1 tons.)

Position	Torque Meter Reading in Lb.Ft.	Torque at Final Drive Sprocket Shaft in Lb.Ft.	Torque at Transmission Drive Sprocket in Lb.In.
Pivot Steering Right Turn Forward			
Right Track	-5200	-13,880	-17,820
Left Track	+7200	+19,210	+24,650
Pivot Steering Left Turn Forward			
Right Track	+7000	+18,680	+24,000
Left Track	-5750	-15,340	-19,700
*Pivot Steering Right Turn Reverse			
Right Track	-4800	-12,790	-16,420
Left Track	+7600	+20,250	+26,020
*Pivot Steering Left Turn Reverse			
Right Track	+7100	+18,130	+23,270
Left Track	-6400	-17,090	-21,930
Right Turn Full Steer at 4.88 mph			
Right Track	-3200	- 8,540	-10,960
Left Track	+5700	+15,200	+19,520
Left Turn Full Steer at 4.88 mph			
Right Track	+6200	+16,540	+21,220
Left Track	-3600	- 9,600	-12,660
Right Turn Full Steer at 9.35 mph			
Right Track	-3800	-10,130	-13,100
Left Track	+5800	+15,490	+19,880

*Test platform would not turn in reverse. The engine could not supply sufficient torque at this gear ratio (135.7:1).

Table 6. Drawbar Pull

(Tire size 16 x 24-6. Air temperature 25°F. to 35°F.)

Terrain	Drawbar Pull Pounds	Remarks
	Tire Pressure 5 psi	
Concrete Ramp	9,500	
Gravel Road	11,500	
Asphalt Road	16,875	
	Tire Pressure 10 psi	
Concrete Ramp	8,875	Not ideal conditions. Surface conditions became muddy due to temperature rise.
Gravel Road	10,750	
Asphalt Road	10,250	
	Tire Pressure 15 psi	
Concrete Ramp	8,375	Drawbar failed.
Gravel Road		
Asphalt Road		

Note: Intermittently during the test the track broke traction and whenever this occurred the tires slipped on the ground and sponson simultaneously.

Table 7. Pressure Build Up

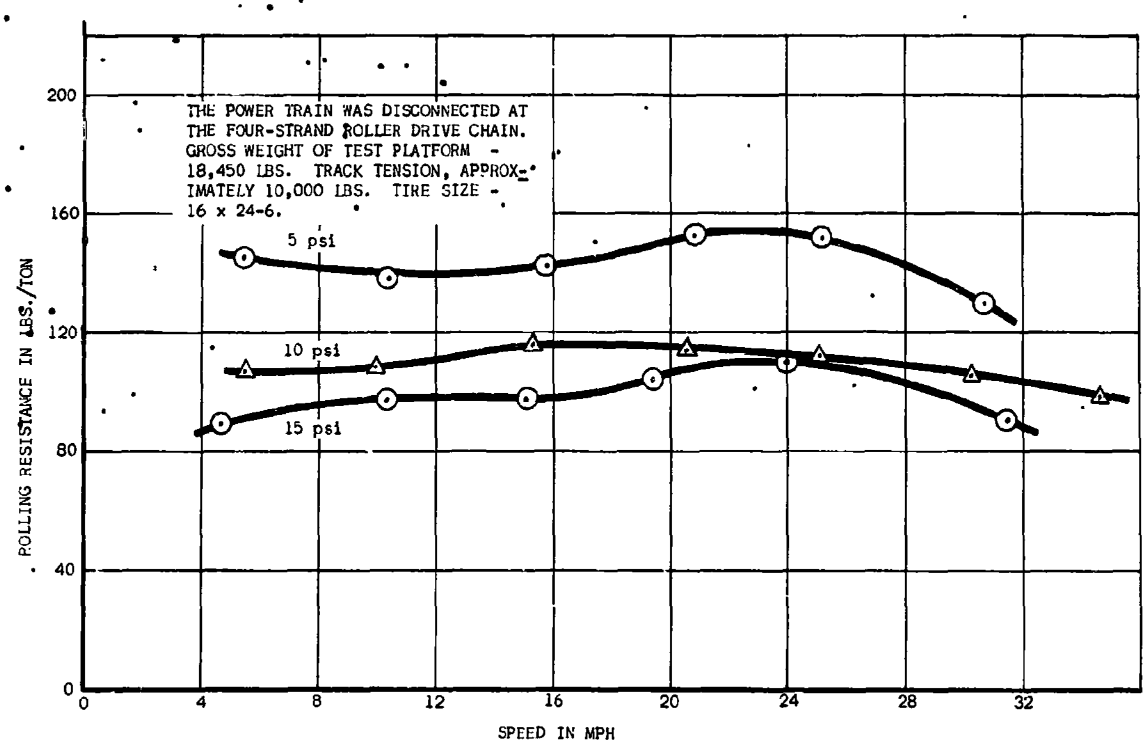
(Terra tire 16 x 24-6, four ply smooth tread. Diametrically loaded. This data is interpolated from Goodyear Tire and Rubber Company, Graph No. 521201-106, dated 11 March 1958.)

Deflection Percentage	Tire Pressure (psi) 0	2	4	6	6.5	8	10	12	13
10	0.10	2.10	4.15	6.20	6.70	8.20	10.25	12.25	13.25
20	0.45	2.60	4.80	6.95	7.50	9.05	11.15	13.25	14.30
30	1.25	3.60	5.95	8.25	8.85	10.95	12.75	15.00	16.10
40	2.70	5.25	7.80	10.35	10.95	12.80	15.25	17.70	18.95
50	5.15	8.05	10.90	13.80	14.50	16.65	19.55	22.55	23.90

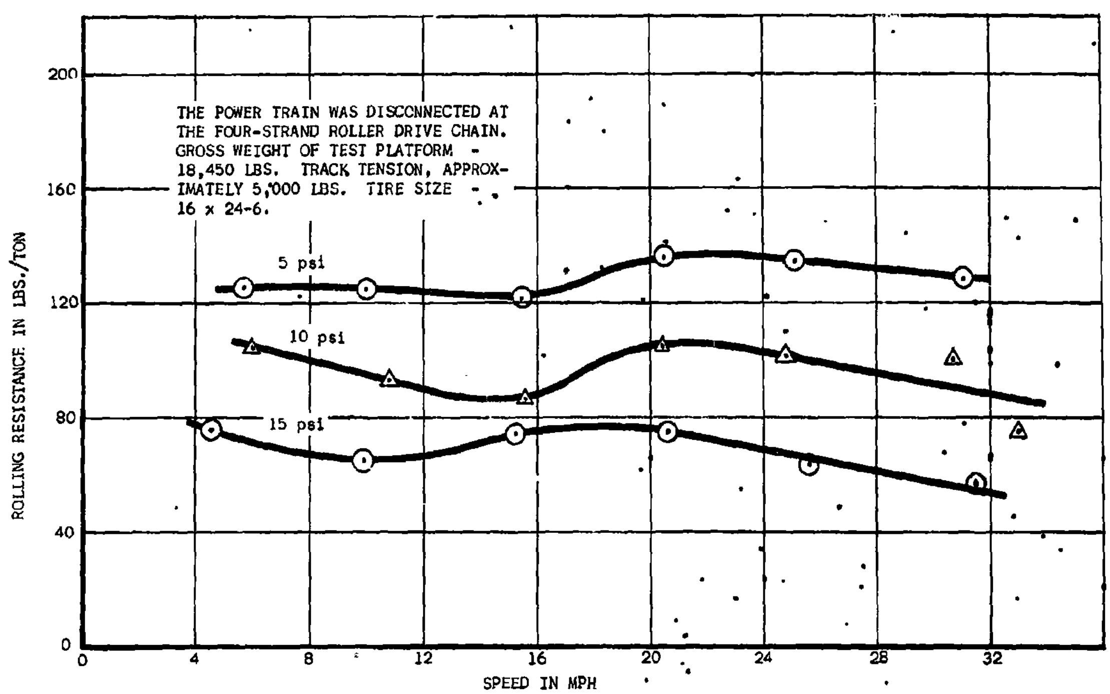
Table 8. Tire Loadings (Pounds)

(Terra tire 16 x 24-6, four ply smooth tread. Diametrically loaded. This data is interpolated from Goodyear Tire and Rubber Company, Graph No. 52120-107, dated 11 March 1958.)

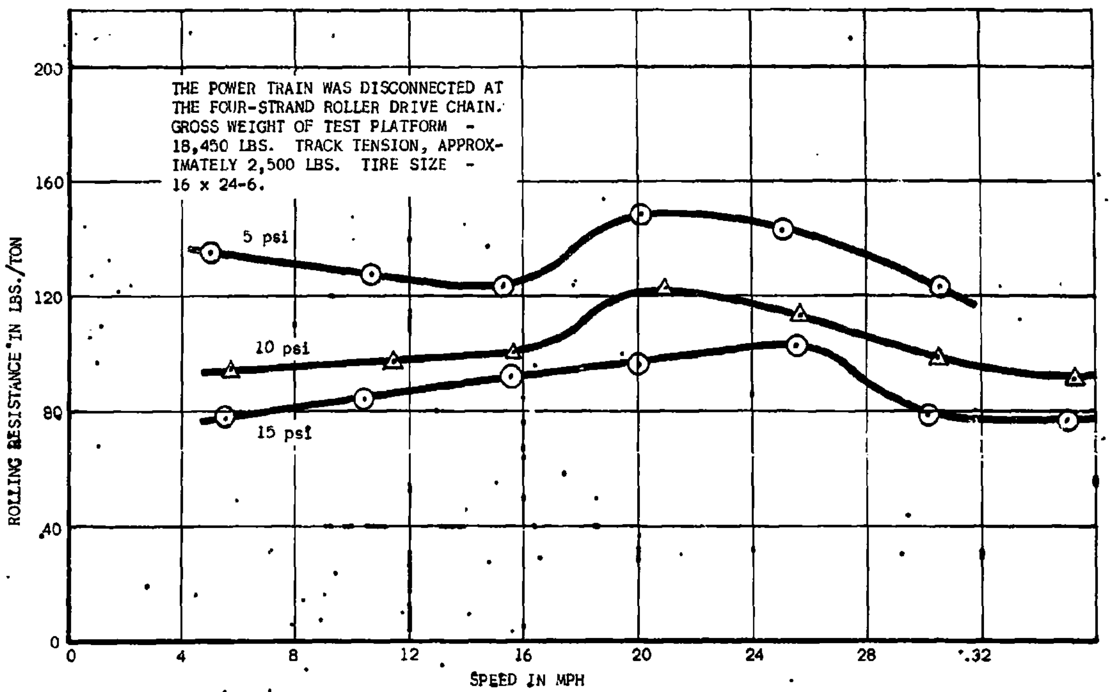
Deflection Percentage	Tire Pressure (psi) 0	2	4	6	6.5	8	10	12	13
10	0	130	260	390	425	535	683	825	850
20	75	345	615	885	950	1,140	1,395	1,650	1,775
30	350	760	1,165	1,575	1,675	1,995	2,415	2,825	3,050
40	850	1,465	2,080	2,600	2,850	3,335	3,980	4,625	4,950
50	1,800	2,695	3,600	4,500	4,700	5,440	6,425	7,400	7,900



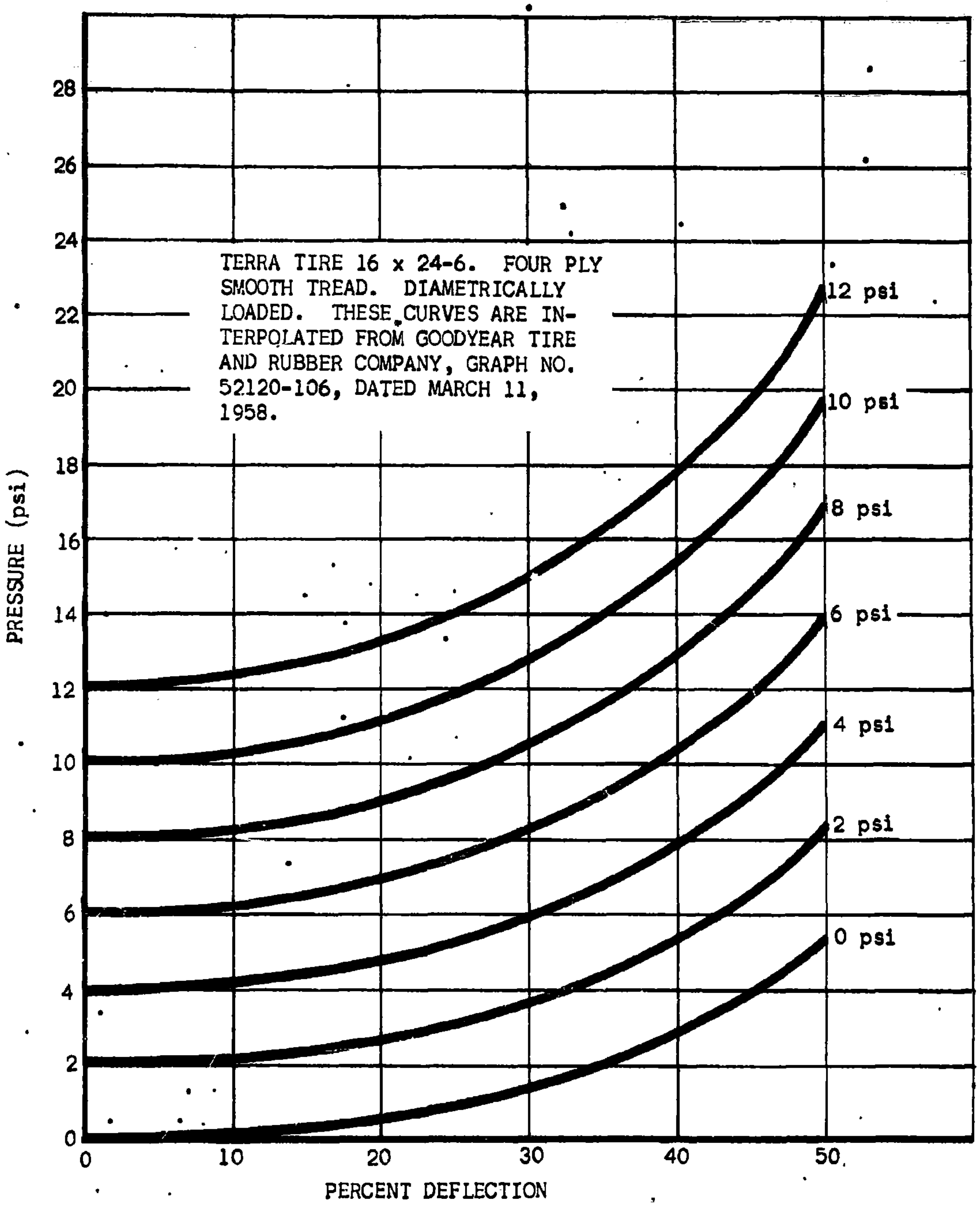
Graph 1. Rolling Resistance Versus Test Platform Speed



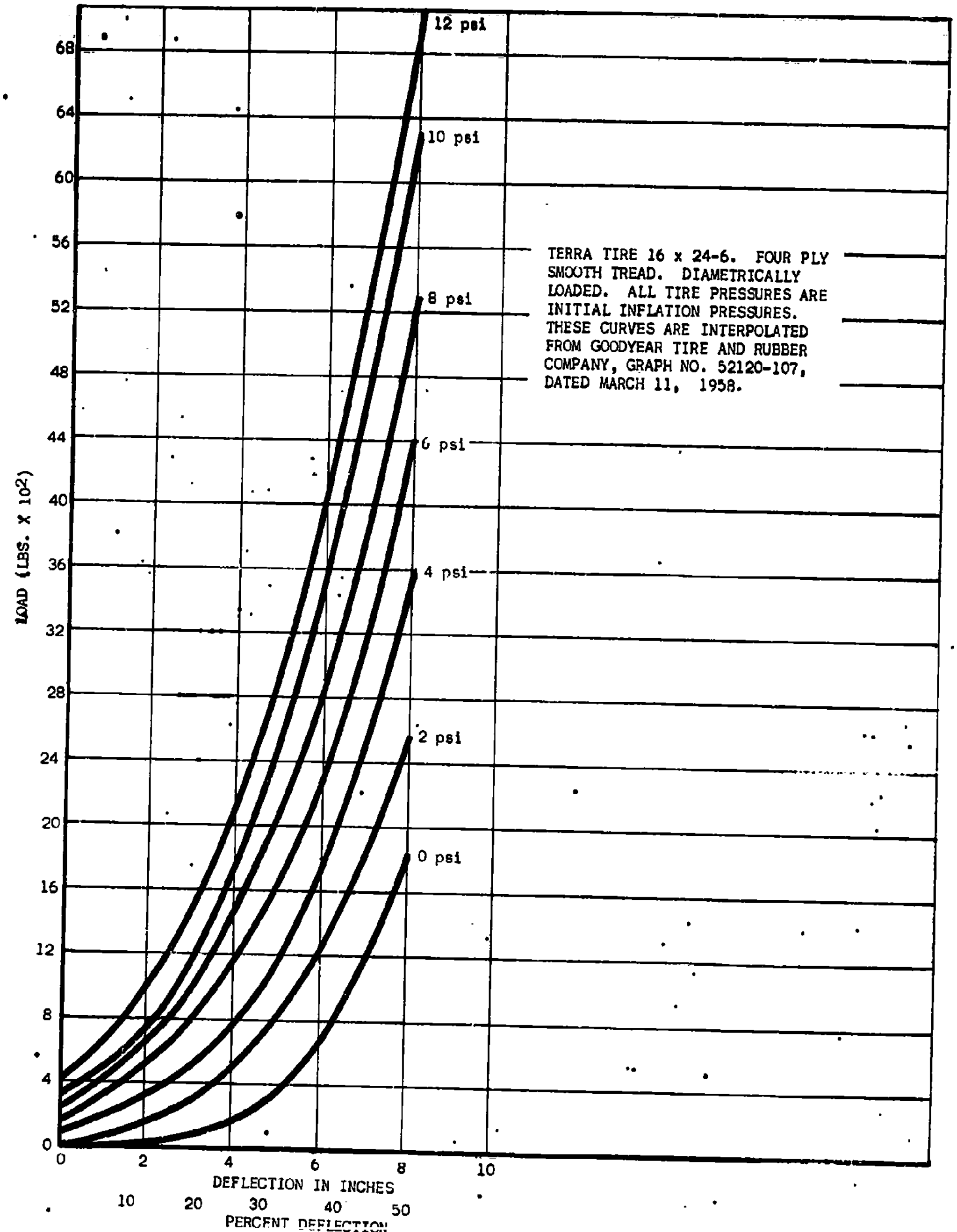
Graph 2. Rolling Resistance Versus Test Platform Speed



Graph 3. Rolling Resistance Versus Test Platform Speed



Graph 4. Tire Pressure Build Up Versus Deflection in Percent of Diameter



Graph 5. Load Versus Deflection in Inches and Percent of Diameter

TEST AGENDA

for

AIROLL TEST PLATFORM

Contract NOnr-2459(00)

As this test program progresses the test results may require additional testing or modifications in the sequence of testing. Therefore this agenda is intended to be used primarily as a guide and will retain the flexibility required to allow the most advantageous and expeditious test operation.

Part I - Static and dynamic testing that does not require electronic instrumentation.

A. Preoperational check outs to be accomplished and information to be obtained.

1. Install engine intake manifold vacuum gage.
2. Check test platform for proper lubrication.
3. Obtain weight of test platform (empty).
4. Determine the center of gravity (longitudinal and vertical).

B. Power train break-in.

1. Elevate the test platform on blocks to a point where the tracks will not make physical contact with the pavement. Operate the power train in each transmission gear ratio at the following engine speeds:

   a. Idle - 15 minutes.

b. 1,000 rpm - 15 minutes.

c. 1,600 rpm - 15 minutes,

d. 2,400 rpm - 15 minutes.

e. 3,200 rpm - 10 minutes.

f. 3,600 rpm - 5 minutes.

2. Monitor the power train for this period to assure proper operation, alignment and wear in characteristics.

   a. Continually check the operation of the Allison steering transmission.

C. Rolling resistance.

1. Utilizing the 24 x 24 x 6 terra tire with an operating pressure of 4 psi (checked with a mercury manometer) with no payload on the test platform, adjust the track tension so that the test platform can be pivot steered to the port or starboard without the track slipping or jumping from the drive sprockets. Maintaining constant track tension, determine the rolling resistance of the test platform on a dry level concrete surface at test platform speeds of:

   a. 5 mph.

   b. 10 mph.

   c. 15 mph.

   d. 20 mph.

   e. 25 mph.

f. 30 mph.

g. 35 mph.

h. 40 mph.

2. Repeat C.1. above with a tire pressure of 8 psi.

3. Repeat C.1. above with a tire pressure of 12 psi.

4. Repeat C.1. above with a tire pressure of 15 psi.

5. Repeat C.1. through C.4. above with the test platform uniformly loaded with 2,000 pounds.

Part II - Power testing requiring electronic instrumentation.

A. Install torquemeters (68,000 pound inch) in each drive sprocket input shaft and the proper portable electronic instrumentation required to obtain values. Check the test set up with known torque values and properly calibrate the instruments and record calibration figures.

B. Determination of the friction horsepower absorbed by the tracks.

1. With a tire pressure of 4 psi and no load on the test platform, adjust the track adjusting nut to the value obtained in Part I.C.1. Elevate the vehicle to a point where the test platform applies no load to the track but leaving the track in contact with the ground. Operate the power train and record the input torque and speed at the following track speeds:

a. 2.5 mph.

b. 5.0 mph.

c. 7.5 mph.

d. 10.0 mph.

e. 12.5 mph.

f. 15.0 mph.

g. 17.5 mph.

h. 20 mph.

2. Repeat B.1. above with a tire pressure of 8 psi.

3. Repeat B.1. above with a tire pressure of 12 psi.

4. Repeat B.1. above with a tire pressure of 15 psi.

5. Repeat B.1. through B.4 above with the test platform uniformly loaded with 2,000 pounds.

C. Determine the horsepower required to move the test platform at constant velocity.

1. With no payload, a tire pressure of 4 psi and the track tension properly adjusted, determine the drive sprocket input speed and torque on a dry level concrete surface at test platform speeds of:

a. 5 mph.

b. 10 mph.

c. 15 mph.

d. 20 mph.

e. 25 mph.

f. 30 mph.

g. 35 mph.

h. 40 mph.

2. Repeat C.1. above with a tire pressure of 8 psi.

3. Repeat C.1. above with a tire pressure of 12 psi.

4. Repeat C.1. above with a tire pressure of 15 psi.

5. Repeat C.1. through C.4. above with the test platform uniformly loaded with 2,000 pounds.

D. Determine the torque required to steer the test platform on dry level concrete.

1. With no payload and maintaining proper track tension, determine the torque required to pivot steer to port and starboard, (include the negative braking torque and the positive driving torque) both forward and reverse, at the following tire pressures:

a. 4 psi.

b. 8 psi.

c. 12 psi.

d. 15 psi.

2. Repeat D.1. above with the test platform uniformly loaded with 2,000 pounds.

3. Determine the torque (include the negative braking torque and positive driving torque) required to steer the test plat-

form with no payload through a full steer turn of 180 degrees at test platform speeds of 5, 10, 15 and 20 mph for tire pressures of:

a. 4 psi.

b. 8 psi.

c. 12 psi.

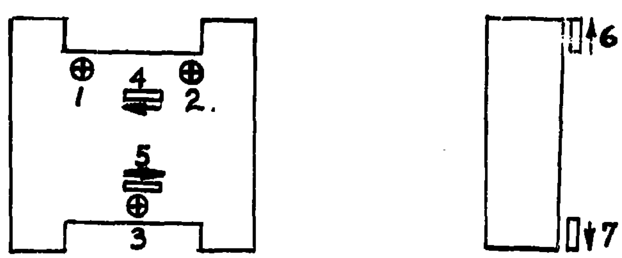
d. 15 psi.

4. Repeat D. 3. above, the test platform uniformly loaded with 2,000 pounds.

Part III - Vibration and ride characteristics tests.

A. The following instrumentation and data collection will be required for each run of Part III,

1. Install 7 linear accelerometers on the test platform at the following locations.



Top View   Side View

2. Connect the accelerometers to a portable electronic recorder mounted on the test platform that is equipped with

the facility to integrate the acceleration signal and obtain the velocity attained with each acceleration.

3. Accelerometers 1, 2 and 3 will give the:

   a. Vertical acceleration of the center of gravity.

   b. Rotational (pitch and roll) acceleration about the center of gravity.

   By integrating these functions the following velocities are obtained:

   (1) Vertical velocity of the center of gravity.

   (2) Rotational (pitch and roll) velocity about the center of gravity.

4. Accelerometers 4 and 5 will give the,

   a. Rotational (yaw) acceleration about the center of gravity, and

   b. Integrating this function the rotational (yaw) velocity about the center of gravity is obtained.

5. Accelerometer 6 and 7 will give the,

   a. Forward acceleration of the center of gravity, and

   b. Integrating this function the forward velocity of the center of gravity can be obtained.

6. Utilize a fifth wheel to enable the operator to control the speed of the test platform during testing.

7. Adjust track tension for each test run in accordance with Part I.C. above.

8. All initial test data to be obtained with the terra tire 24 x 24 x 6 and a track length to width ratio of 1 to 1.

B. The following tests are to be run with tire pressures of 4 psi and 15 psi (tire in the free state supporting no external load).

1. With no payload (empty test platform approximate weight 17,500 pounds) on a dry smooth concrete surface obtain the above acceleration and velocity data (2 runs each) at the following test platform speeds (forward):

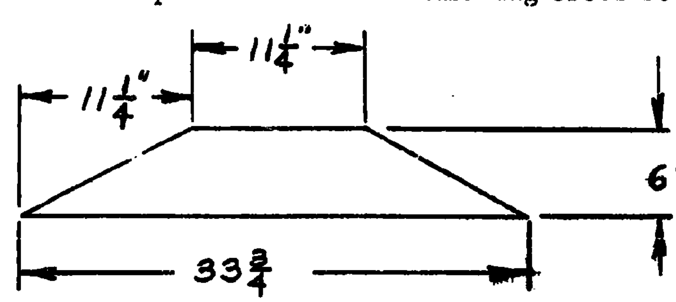
   a. 5 mph.

   b. 20 mph.

   c. 35 mph.

   d. 50 mph.

2. Repeat B.1. above with one trapezoidal bump extending across the test track and perpendicular to the direction of travel of the test platform with the following cross section:



3. Repeat B.1. above with one 6 inch square bump extending across the test track and perpendicular to the direction of travel of the test platform with the two tire contact corners rounded off with a one inch radius.

4. Repeat B.1. above with 8 trapezoidal bumps (described in B.2 above) spaced at the proper distance for the test platform to hit the natural vertical frequency at 20 mph. The natural frequency is found by the equation

$$f = 0.159 \sqrt{\frac{450}{\text{wheel deflection in inches}}}$$

$= $ cycles per second

distance between bumps $= d$

$$d = \frac{20 \text{ mph}}{f} = \frac{29.4 \text{ fps}}{f}$$

$=$ ft.

5. Load the test platform with 2,000 pounds forward, locate the new center of gravity and repeat B.1., B.2. and B.4. above.

6. Load the test platform with 2,000 pounds aft, locate the new center of gravity and repeat B.1., B.2. and B.4. above.

C. The following tests will be run with a tire pressure of 8 psi (tire in the free state supporting no external load).

1. Repeat B.1. and B.2. above.

2. Load the test platform with 2,000 pounds forward as in B.5. above and repeat C.1. above.

D. The following tests will be run with a tire pressure of 12 psi (tire in the free state supporting no external load).

1. Repeat B.1. and B.2. above.

2. Load the test platform with 2,000 pounds aft (as in B.6. above) and repeat D.1. above.

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